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HYDRAULIC SYSTEM AND AUTOMATIC GEARBOX

The invention relates to a hydraulic system with a multi-flow, especially a dual-flow hydraulic pressure supply unit, such as a pump, through which a volume flow is fed to a consumer. The invention also concerns an automatic transmission for motor vehicles.

In modern motor vehicles, hydraulic systems in which at least one pressure supply unit supplies at least one consumer with a defined pressure are being used to improve safety and comfort. The known hydraulic systems indeed have a high power density, a low power-weight ratio and high dynamics, but nonetheless require more energy in relation to regulated electric drives, which leads to higher fuel consumption. Previously mostly single-flow pumps have been used to supply pressure to, for example, automatic transmissions. Single-flow here means that the pump conveys one pump flow. In contrast, multi-flow pumps convey several pump flows independently of one another. The pump flows are thus connected in parallel.

The object of the invention is to reduce the losses in known hydraulic systems. Here the hydraulic pressure supply unit used in the hydraulic system should meet the demands of the automotive industry over a wide range of hydraulic requirements.

The object is accomplished in a hydraulic system with a multi-flow, especially dual-flow, hydraulic pressure supply unit, such as a pump, through which a volume flow is fed to a consumer, in that a valve apparatus for switching between the individual pump flows and/or for interconnecting the individual pump flows is provided. The valve apparatus enables actuating the individual pump flows selectively. It is possible as needed to actuate only one or several pump flows with a single valve

apparatus.

A preferred embodiment of the hydraulic system is characterized in that the individual pump flows are joined or separated through a stop valve. The stop valve makes it possible to carry away at least one of the pump flows so that optionally only at least one of the pump flows is conveyed to the consumer.

A further preferred embodiment of the hydraulic system is characterized in that the at least one pump flow, which is separated by the stop valve from the at least one other pump flow, can be carried away through the valve apparatus. Only one pump flow or several pump flows are supplied to the consumer as a function of the setting of the valve apparatus. The stop valve prevents all pump flow from being evacuated.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus comprises a surface pre-stressed by a spring-loaded apparatus, said surface being acted upon with the dynamic pressure of a feedback leading from the consumer to the input side of the hydraulic pressure supply unit. The use of the feedback dynamic pressure for actuating the valve apparatus guarantees that the valve apparatus switches from a single-flow to an at least dual-flow conveyance of the hydraulic pressure supply unit when the feedback dynamic pressure drops below a specified minimum value. If the feedback dynamic pressure exceeds a specified maximal value, the valve apparatus switches from an at least dual-flow to an at least single-flow conveyance of the hydraulic pressure supply unit.

A further preferred embodiment of the hydraulic system is characterized in that a hydraulic resistor is arranged between the valve apparatus and the input side of the hydraulic pressure supply unit. The hydraulic resistor serves to generate the feedback

dynamic pressure for actuating the valve apparatus.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus includes a 2/2 way valve that releases a connection provided between the output side of a pump flow and the input side of the hydraulic pressure supply unit in the one position, said connection being interrupted in the other position of the 2/2 way valve. The 2/2 way valve makes it possible to feed the two pump flows to the consumer individually or together depending upon need.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus has three shifting stages, whereby in the first shifting stage a cooling circuit is not supplied and only one pump flow is conveyed to the consumer by the hydraulic pressure supply unit, whereby in the second shifting stage the cooling circuit is not supplied and at least two pump flows are conveyed to the consumer from the hydraulic pressure supply unit, and whereby in the third shifting stage, the cooling circuit is supplied and at least two pump flows are conveyed to the consumer from the hydraulic pressure supply unit. The shifting stages make it possible to use the valve apparatus, which can be actuated as needed, for also turning the cooling system on and off, for example a clutch.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus has a further shifting stage in which the cooling circuit is not supplied and a safety valve is activated. The safety valve can serve, for example, to prevent overheating of the medium conveyed or represents a redundant opening mechanism for a clutch.

A further preferred embodiment of the hydraulic system is characterized in that

the valve apparatus, especially as a 2/2 way valve, is designed such that only one pump flow is conveyed from the hydraulic pressure supply unit to the consumer as long as a first pressure, especially the adjustment pressure of an automatic transmission, is smaller than or equal to the sum of a second pressure, especially the contact pressure of an automatic transmission, and of a spring force, and in that at least two pump flows are conveyed from the hydraulic pressure supply unit to the consumer if the first pressure, especially the adjustment pressure of an automatic transmission, is greater than the sum of the second pressure, especially the contact pressure of an automatic transmission, and of the spring force. In this way, it is guaranteed that connection of at least one further pump flow will take place as a function of need.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus includes a tappet whose one face is acted upon with the first pressure and whose other face is acted upon by the second pressure and spring force. The tappet moves as a function of the forces acting upon it and thus releases a flow path for one or more pump flows.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus performs even additional valve functions in addition to turning on or shutting off the pump flow (= first valve function) in that the valve tappet releases or closes openings on other control units. These additional valve functions can, for example, be an application of pressure on a hydraulic clutch, or the application of pressure on the cone pulleys of an infinitely variable transmission. The coupling of the first valve function with a further valve function represents a cost advantage because,

instead of two slides and boreholes, only one need be manufactured or machined. The coupling of the first valve function with a further valve function likewise represents a functional advantage if a volume flow requirement is actuated through the further valve function whose coverage takes place in the same valve by turning on a pump flow. The coupling of the first valve function with a further valve function likewise represents a functional advantage when these valve functions can take place in connection with different motions of the tappet, that is, in part independently. For example, the additional valve function can represent the application of pressure on a clutch for the second gear, and the tappet now permits connecting an additional pump flow when the clutch is not activated by a further motion of the tappet. This control and especially further displacement of the tappet takes place in a known manner, for example by applying a small electronically controlled pressure to a face of the tappet.

A further preferred embodiment of the hydraulic system is characterized in that the valve apparatus includes at least two valves whose switching respectively brings about the conveyance of at least one of the pump flows to the consumer. Both valves in each case assume even further functions as described above, for example respectively subjecting a clutch to pressure.

A further preferred embodiment of the hydraulic system is characterized in that the two valves are connected in series. Switching from one of the two valves leads to at least one of the pump flows being conveyed to the consumer. The at least one pump flow is conveyed back to the input side of the hydraulic pressure supply unit.

A further preferred embodiment of the hydraulic system is characterized in that a volume flow regulating valve is arranged between the output side of the pressure

supply unit and the consumer. The volume flow regulating valve serves to regulate the volume flow to the consumer. The excess volume flow is conveyed back to the input side of the hydraulic pressure supply unit.

A further preferred embodiment of the hydraulic system is characterized in that connection/disconnection of individual pump flows takes place as needed. For example, fixed rotational speed thresholds can be defined, at which the switching takes place. Here care should be taken that the requisite need is still being covered when disconnecting a pump flow.

A further preferred embodiment of the hydraulic system is characterized in that the ratio between the individual pump flows is asymmetrical. Due to this, it is possible to convey three different volume flows with one hydraulic pressure supply unit.

A further preferred embodiment of the hydraulic system is characterized in that a first pump flow covers approximately a third and a second pump flow approximately two thirds of the overall conveyed flow of the hydraulic pressure supply unit. With a corresponding control logic, both pump flows together can supply 100% or only one pump flow can supply 33 or 66% of the entire conveyed flow of the hydraulic supply unit, as needed.

A further preferred embodiment of the hydraulic system is characterized in that the hydraulic pressure supply unit includes a vane cell pump or an internal gear wheel pump.

A further preferred embodiment of the hydraulic system is characterized in that a hydraulic resistor is arranged between the valve apparatus and the input of the hydraulic pressure supply unit that includes an injector pump into which the vane cell

pump is incorporated. The injector pump is used to assure proper filling of the preferably mechanically driven pump at higher rotational speeds.

The indicated objective is accomplished in connection with an automatic transmission for motor vehicles through a previously described hydraulic system. The hydraulic system of the invention can also, however, be used in the steering system or the anti-roll system.

Further advantages, features and details of the invention become apparent through the description below, in which various embodiments are described in detail with reference to the drawings. There is shown:

Figure 1 a hydraulic circuit diagram of a hydraulic system of the invention for controlling an automatic transmission;

Figure 2 a block diagram for controlling a dual-flow pump with a valve apparatus and an additional flow regulating valve;

Figure 3 a block diagram for controlling a dual-flow pump with switching dependent upon two different pressures;

Figure 4 a block diagram for controlling a dual-flow pump with a volume flow conductor and

Figure 5 a block diagram for controlling a dual-flow pump with two valves connected in series.

Contemporary automatic transmissions for passenger cars control the starting process, the gear ratio change and the activation for the reversing assembly clutch for forward/reverse travel as well as for cooling and lubricating hydraulically. A hydraulic pressure supply unit and a hydraulic control unit are necessary for this.

Up until now, largely single-flow pumps have been used for supplying pressure to automatic transmissions. The pumps are distinguished in that their conveyed volumes are purely proportional to the rotational speed. This is disadvantageous insofar as, in designing pump sizes, often extreme situations such as, for example, a rapid adjustment at low rotational speeds, are decisive for the designs. In many other driving situations, the volume flow then made available is not necessary. The efficiency of these pumps is not optimal since, for example, unnecessarily much hydraulic power is generated by the mechanically driven pump at maximum speed. Second, the hydraulic components used, such as, for example, the pump, are e.g. subjected to unnecessarily high stress at maximum speed.

A pump concept is created through the present invention in which the required volume flow is generated as a function of need. In this way, the hydraulic dissipation power as well as the pump stress can be reduced. With the hydraulic system of the invention, it proves advantageous that the system pressure can be reduced since at a high system pressure leakages as a rule increase. The actuation of the individual pump flows is preferably conducted such that the net volume flow remains identical. Generating less volume flow at the same rotational speed with cold oil than with warm oil is desirable since at low oil temperatures less leakage is present and consequently the volume flow requirement drops.

It has proven advantageous if a portion of the volume flow made available by the pump is also used for cooling the transmission. With cold outside temperatures, it is advantageous to reduce the volume flow to the point that only the precisely required amount flows through the radiator and consequently heat losses are reduced. With a

very hot transmission, it is advantageous to generate more volume flow than needed to increase heat output.

It has likewise proven to be advantageous if a portion of the volume flow furnished by the pump is also used for cooling individual components of the transmission in danger of overheating, for example, friction clutches. At low friction output, it is advantageous to shut the volume flow off, while at high friction output (starting on a mountain), the required amount of cold oil is poured over the friction clutch to protect the latter from overheating.

A hydraulic control unit for an automatic transmission with a driving disk set 1 and an output disk set 2 is represented in Figure 1. The hydraulic system represented in Figure 1 moreover serves to control a clutch 4 for reverse travel and a clutch 4 for forward travel. Activation of the disk sets 1, 2 and the clutches 4, 5 takes place through a pump 8 in which a first pump flow 9 and a second pump flow 10 are generated parallel to each other. The two pump flows 9 and 10 are brought together through a stop valve 12. An additional valve 14 serves to switch between the two pump flows 9, 10 such that either only pump flow 9 or both the pump flows 9, 10 are conveyed together in the direction of consumers 1, 2, 4, 5.

A preferred embodiment for selective actuation of two pump flows is represented in Figure 2. One pump 18, a vane cell pump, for example, is constructed and designed such that a first pump flow 19 is conveyed parallel to a second pump flow 20. The two pump flows 19 and 20 are connected with each other on the output side of the pump 18 through a conduit 22 in which a stop valve 23 is arranged. The stop valve 23 is arranged in the conduit 22 such that either only the first pump flow 19

or, however, the first pump flow 19 as well as the second pump flow 20 are conveyed through a conduit 24 to a consumer 25. An orifice plate 26 is arranged in the conduit 24 between the output side of the pump 18 and the consumer 25. The orifice plate 26 belongs, as is indicated through a dotted arrow 28, to a flow regulating valve 29, which is arranged between the input side and the output side of the consumer 25 in order to regulate the volume flow that is supplied to the consumer 25. A 2/2 proportional way valve is installed as the flow regulating valve 29. It the volume flow conveyed to the consumer 25 exceeds an adjustable maximum value, then the flow-regulating valve switches into its second position from the position represented in Figure 2. In its second position (not represented), the flow-regulating valve 29 releases a connection from the output side of the pump 18 through the conduit 24 past the consumer to a feedback conduit 30 that leads to a tank 31.

It is indicated by an arrow 32 that the pressure in the feedback conduit 30 serves to control an additional valve apparatus 34. The valve apparatus 34 is a 2/2 proportional way valve that interrupts or releases (not represented) a connecting conduit 35 between the feedback conduit 30 and the output side of the second pump flow 20 of the pump 18. The pressure in the feedback conduit 30 is dammed up in front of the valve apparatus 34 by a hydraulic resistor 36.

With the hydraulic system represented in Figure 2, the valve apparatus 34 is used to convey selectively either only pump flow 19 or the two pump flows 19 and 20 together to the consumer 25. The back pressure in the conduit 30 is used, as indicated by the arrow 32, to switch the valve apparatus 34 against a spring. The hydraulic fluid volume flow flowing back over the feedback conduit 30 into the tank 31

and/or toward the input side of the pump 18 meets the hydraulic resistance 36, which generates the back pressure as a function of the volume flow. The injector pump used in vane cell pumps can, for example, be used as a hydraulic resistor 36. Such an injector pump is needed in vane cell pumps to assure proper filling of the pump at higher rotational speeds. The hydraulic resistor 36 is represented by a baffle in Figure 2.

The dual-flow pump 18 is by way of example driven by a crankshaft of an internal combustion engine and consequently conveys a hydraulic fluid volume stream as a function of rotational speed. The two pump flows 19 and 20 are brought together through the stop valve 23 and are supplied to the consumer 25 through the conduit 24 by the orifice plate 26 in the position of the pilot valve 34 represented in Figure 2. As for the consumer, it can be, as represented in Figure 1, a disk set for adjusting the gear ratios or a clutch in an automatic transmission. Hydraulic fluid flowing back from the consumer 25 through the feedback conduit 30 is supplied to the pump 18 again through the hydraulic resistor 36.

If the rotational speed of the pump 18 is increased, then more hydraulic fluid is conveyed and fed to the consumer 25. The return of hydraulic fluid over the feedback conduit 30 to the suction tract of the pump 18 is correspondingly higher. The back pressure on the hydraulic resistor 36 increasing owing to this leads to the valve apparatus 34 shortcircuiting the second pump flow 20 of the pump 18 with the back-flowing hydraulic fluid in the feedback conduit 30. In this way, the pressure of the pump flow 20 declines to the back pressure in the feedback conduit 30 and closes the stop valve 23. The second pump flow 20 of the pump 18 is then switched to recycling

and needs only still convey against the back pressure in the feedback conduit 30, which would be present in any case. In this way, the output consumption of the pump 18 is reduced.

If the rotational speed of the pump 18 and therewith of the volume flow fed to the consumer 25 increases, then the volume flow regulating valve 29 in connection with the orifice plate 26 restricts the volume flow to the consumer 25. The hydraulic system represented in Figure 2 affords the advantage that the second pump flow 20 is only added when needed. If the consumer 25 needs more hydraulic fluid and consequently no or little hydraulic fluid is being passed back through the flow regulating valve 29 and the feedback conduit 30 to the tank 31 or toward the input side of the pump 18, then the volume flow declines due to the hydraulic resistor 36 and therewith the back pressure in the feedback conduit 30. This causes the valve apparatus 34 to close, and the hydraulic fluid volume flow of the second pump flow to be conducted back to the consumer 25, as represented in Fig. 2. This ensures the increased need for hydraulic fluid. If the need of the consumer 25 declines again, then correspondingly more hydraulic oil is fed back, which leads to a renewed switching of the second pump flow 20 to recycling without pressure.

A cutaway of a hydraulic block diagram is represented in Fig. 3 in which a valve apparatus for need-dependent volume flow generation is designated with 37. The valve apparatus 37 includes a valve housing 38 that is connected with the output side of a pump with two pump flows 41 and 42 through a conduit 39. The two pump flows 41 and 42 are connected with each other through a conduit 45 in which a stop valve 46 is arranged. The fact that the output side of the pump flows 41 and 42 is connected

with a consumer (not represented) is indicated by an arrow 47. The input side of the pump flows 41 and 42 is connected with a hydraulic tank 49. A conduit 50 leads from the hydraulic tank 49 to the valve housing 38. A tappet 52 is pre-stressed against a spring 53 in the valve housing 38. The face of the tappet 52 facing the spring 53 is acted upon with a pressure P1. The face of the tappet 52 facing away from the spring 53 is acted upon with a pressure P2.

In the state of the valve apparatus 37 represented in Figure 3, the pump flow 42 is conveyed in a circle through the conduit 50 and does not reach the consumer. Only the pump flow 41 reaches the consumer through conduit 47. It is assured through the stop valve 46 that pump flow 41 does not reach the valve housing 38 through conduit 39. When the tappet 52 moves such that the conduit 39 is closed, the pressure at the output of the pump flow 42 rises until the stop valve 46 in the conduit 45 releases the connection to the pump flow 41. Then both pump flows 41 and 42 are conveyed to the consumer. Connection of the pump flow 42 to pump flow 41 takes place when the product of a first constant with adjusting pressure P2 is greater than the sum from the product of a second constant with the contact pressure P1 and the force of the spring. The pressures P1 and/or P2 can alternatively be a pressure that controls a function requiring volume flow already present in the hydraulic control unit, or a pressure generated by an electric control apparatus by pilot valve.

The circuit diagram of a hydraulic system is represented in Figure 4 in which a first pump flow 56 as well as a second pump flow 57 of a vane cell pump are fed from a tank 55. The two pump flows 56 and 57 are connected with each other through a stop valve 58. The output of the first pump flow 56 is connected with a valve housing

62 of a valve apparatus 63 through a conduit 60. The second pump flow 57 is connected with the valve housing 62 through a conduit 61. A tappet 64 is moveably accommodated in the valve housing 62 of the valve apparatus 63. The tappet can assume even further functions in the region not represented, in that oil channels are closed or opened according to the position of the tappet. A connection to a consumer (not represented) is indicated by an arrow 65 that proceeds from the valve housing 62. Moreover a feedback conduit 66 proceeds from the valve housing 62 and opens into the tank 55.

In the position of the tappet 64 represented in Figure 4, the first pump flow 56 is conveyed over the conduits 60 and 65 to the consumer. The second pump flow 57 is conveyed back into the tank 55 through conduit 61 and the feedback conduit 66. when the tappet 64 is moved to the right, the connection between the conduit 61 and the feedback conduit 66 is interrupted, which leads to the pressure rising on the output side of the second pump flow 57 until the stop valve 58 opens and the two pump flows 56 and 57 are conveyed together over conduits 60 and 65 to the consumer.

A circuit diagram of a hydraulic system is represented in Figure 5 in which a first pump flow 71 as well as a second pump flow 72 are fed with hydraulic fluid from a tank 68. The two pump flows 71 and 72 are connected with each other through a stop valve 73. A conduit to consumers (not represented) is indicated by an arrow 74. A connection between the output side of the second pump flow 72 to a valve housing 76 of a first valve is indicated by an arrow 75. A tappet 77 is accommodated displaceably in the valve housing 76. The valve housing 76 of the first valve is connected with a valve housing 79 of the second valve through a conduit 78. A tappet 80 is moveably

accommodated in the valve housing 79 of the second valve. The valve housing 79 of the second valve stands in connection with the tank 68 through a feedback conduit 81.

Each of the valves represented in the regions not represented on the left can assume even further functions with the same tappet in that oil channels are closed or released. For example, clutches can be acted upon by pressure, or in particular consumers requiring volume flow such as a cooling system can be switched on.

The second pump flow 72 is conveyed over the conduits 75, 78 and 81 back into the tank 68, thus in the circuit in the position of the tappets 77 and 80 in the associated valve housings 76 and 79 represented in Figure 5. The connection between the two pump flows 71 and 72 is interrupted by the stop valve 73. If one of the tappets 77 and 80 is moved to the right against the associated stop, then the feedback into the tank 68 is interrupted. This leads to a rise in pressure on the output side of the second pump flow 72. The pressure on the output side of the second pump flow 72 rises until the stop valve 73 opens, and both pump flows 71 and 72 are jointly conveyed over the conduit 74 to the consumer. The two valves with valve housings 76 and 79 are thus connected in a row or in series.

The patent claims submitted with the application are formulation proposals without prejudice to obtaining further-reaching patent protection. The applicant reserves the right to claim additional feature combinations previously disclosed only in the description or the drawings.

References in the dependent claims refer back to the further development of the object of the main claim by the features of the respective dependent claim. They are not to be understood as a waiver of attaining an independent, objective protection

for the feature combinations of the referred back dependent claims.

Since the objects of the dependent claims can form their own and independent inventions with respect to the state of the art on the priority day, the applicant reserves the right to make them the object of independent claims or applications for division. They can furthermore also contain independent inventions that have an independent configuration from the objects of the preceding dependent claims.

The embodiments are not to be understood as a restriction of the invention. Rather numerous changes and modifications are possible in the framework of the present invention, especially such variants, elements and combinations and/or materials that can be inferred, for example, by combination or modification of individual features in combination with the general description and embodiments as well as features described in the claims and contained in the drawings or elements and procedural steps which can be inferred by the specialist with respect to accomplishing the objective and lead by combinable features to a new object or new procedural steps or new procedural step sequences, also to the extent that they concern manufacturing, testing and operating procedures.